Organizing for Innovation: Does AFWERX Answer DoD's Call?

A Monograph

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Abstract

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The *2018 National Defense Strategy* directs the DoD to organize for innovation in order to maintain a competitive advantage in today's strategic environment. Utilizing organization design theory and historical case studies, this monograph develops a hypothesis that identifies a structural design allowing large, competitive organizations to adopt disruptive technological innovation and the factors that enable the design's success. Through these lenses, the monograph will then evaluate the suitability of AFWERX as a response to the DoD's mandate. Ultimately, the author concludes that because the DoD leverages an ambidextrous design enabled by insulation from bureaucratic processes, senior-level support, clear vision, and a deliberate technology transfer strategy, the creation of AFWERX is an apt organizational adaptation to a changing strategic landscape.

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Abbreviations

AEO	Adaptive Execution Office
AFRL	Air Force Research Laboratory
AI	Artificial Intelligence
ARPA	Advanced Research Projects Agency
ATMS	Army Tactical Missile System
CSAF	Chief of Staff of the Air Force
CIA	Central Intelligence Agency
DARPA	Defense Advanced Research Projects Agency
DDR&E	Director of Defense Research and Engineering
DIUx	Defense Innovation Unit-Experimental
DoD	Department of Defense
GAO	Government Accountability Office
IDA	Institute for Defense Analyses
IP	Intellectual Property
ISR	Intelligence, Surveillance, and Reconnaissance
JSTARS	Joint Surveillance Target Attack Radar System
MAAG-V	Military Assistance Advisory Group Vietnam
MDO	Multi-Domain Operations
NASA	National Aeronautics and Space Administration
NDS	National Defense Strategy
OSD	Office of the Secretary of Defense
OTA	Other Transaction Agreement
PIA	Partnership Intermediary Agreement
PSAC	President's Science Advisory Committee
R&D	Research and Development

RMA	Revolution in Military Affairs
SecDef	Secretary of Defense
SIF	Squadron Innovation Funds
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
USAF	US Air Force
USSOCOM	US Special Operations Command

Introduction

"All planning, particularly strategic planning, must pay attention to the character of contemporary warfare."[1] Heeding Clausewitz's advice, the *2018 National Defense Strategy* (NDS) assesses that today's rapid technological advancements have changed the character of war in a way that "risks eroding the conventional overmatch to which our Nation has grown accustomed."[2] Citing the broad availability of disruptive commercial technology, the Department of Defense (DoD) has called for reform that will allow the department to rapidly harness these game-changing innovations while concurrently rebuilding traditional military readiness. Former Secretary of Defense James Mattis emphasized the importance of balancing these competing priorities. He stated, "It's an equal obligation for me not just to maintain the current readiness, but to make certain that the secretary of defense after next has the same advantages … the same competitive edge that I enjoyed growing up in this country."[3]

As part of the strategy's third line of effort to reform the department for greater performance and affordability, Secretary Mattis directed the DoD to "organize for innovation."[4] Finding the current bureaucratic approach to be risk averse and unresponsive, he charged service secretaries and agency heads with making the required changes to organizational structures that would empower the warfighter.[5] DoD leaders have acknowledged that although innovation is abundant, the organization's challenge lies in its ability to adopt innovative technology.[6] This

[1] Carl von Clausewitz, *On War*, ed. Michael Howard and Peter Paret (Princeton: Princeton University Press, 1976), 220.

[2] US Department of Defense, *Summary of the 2018 National Defense Strategy (NDS) of the United States of America: Sharpening the American Military's Competitive Edge* (Washington, DC, 2018), 3.

[3] Terry Moon Cronk, "DoD's Innovation Initiative Remains Top Priority, Mattis Says," *DoD News*, August 10, 2017, accessed February 8, 2020, https://www.defense.gov/Explore/News/Article/Article/1275181/.

[4] US DoD, *2018 NDS*, 10.

[5] US DoD, *2018 NDS*, 10.

[6] Aaron Boyd, "For DOD, Innovation Isn't the Problem. So What Is?" *Nextgov*, September 5, 2019, accessed February 8, 2020, https://www.nextgov.com/cio-briefing/2019/09/dod-innovation-isnt-problem-so-what/159670/.

has driven the department to seek organizational structures that encourage both current military readiness and the adoption of disruptive innovation.

This monograph develops a hypothesis that identifies a structural design allowing large, competitive organizations to adopt disruptive technological innovation and the factors that enable the design's success. First, the author will review organizational design theory for a social science-based perspective on the problem. Second, recognizing that this is not the first time the DoD has faced an innovation imperative, the author will analyze two historical case studies to determine the factors that contributed to their widely acknowledged success during the Cold War. Finally, this monograph will consider unique aspects of today's strategic environment and apply the theoretical and experiential observations to determine if the DoD's most recent organizational changes, particularly the creation of AFWERX, are a reasonable response to the NDS mandate. Ultimately, the monograph concludes that because the DoD leverages an ambidextrous design (one utilizing seemingly inconsistent structures) enabled by insulation from bureaucratic processes, senior-level support, clear vision, and a deliberate technology transfer strategy, the creation of AFWERX is an apt organizational adaptation to a changing strategic landscape.

The Evolution of Organizational Design

Answering the NDS challenge to improve the DoD's ability to harness innovation requires making informed organizational changes. Therefore, it is instructive to review the evolution of organizational design in order to glean important lessons from theorists in the field. This chapter will examine foundational literature on organizational design in general before honing in on a specific theory addressing the best organizational design for embracing technological innovation.

There is no single focus of study in organization theory. Researchers have written on a variety of organizational facets ranging from purely descriptive narratives on structure to prescriptive ways to drive efficiency, change culture, and adapt to changing environments.

Throughout the history of the discipline, there has been a tension between researchers focused on an ideal structure for process-based efficiency and those who hold other factors such as leadership, culture, and external events to be most influential. While much research seems to imply a choice between the two concepts, the author finds theories that unite both ideas to be the most informative, premised on the idea that both structure and human factors drive success. Similarly, when an organization aims to innovate, a structure that allows for both incremental improvement and disruptive innovation is most appealing.

Origins of Organization Theory

Throughout history, leaders of governments, public administration, and private industry have pondered how best to organize their respective groups in order to accomplish their purpose. As early as 1491 BC, Moses grappled with establishing a hierarchical authority for Israel's judicial system, acknowledging that the task was too great for one person to bear.[7] Although evidence of organizational design exists for centuries prior, organizational theory did not garner significant scholarly interest in the West until the early 1920s. Since then, the field has grown and evolved to explore the many facets of organizations.

Classic Theory

Classic views of organization theory have their roots in the literature of the industrial revolution. Theorists of the 1920s were influenced heavily by the ideas of Adam Smith, Frederick Winslow Taylor, and Max Weber. The ideas of these three authors prompted researchers to focus on hierarchical structure and scientific processes to gain organizational efficiency in a time of technological change.

In his 1776 work *An Inquiry into the Nature and Causes of the Wealth of Nations*, Adam Smith articulated the economic benefits of division of labor in the workplace. By dividing the work of a pin-maker into eighteen discrete tasks and distributing these tasks between specialized

[7] Jay M. Shafritz and J. Steven Ott, *Classics of Organization Theory*, 4th ed. (Fort Worth: Harcourt Brace College Publishers, 1996), 29.

workers and proper machinery, factory managers could gain exponential improvements in production. Smith theorized that as each individual became an expert in his particular function, he would improve his dexterity through repetition and discover easier ways to accomplish his work.[8] Ultimately, the assertion that division of labor in an organization increased productivity and encouraged innovation became the foundation of classic thinking.

Contributing to Smith's goal of maximizing efficiency in factory work, Frederick Winslow Taylor pioneered scientific management to determine the "one best way" of performing a task. Based on trial-and-error research in his steel company, Taylor attempted to use scientific methods to drive production processes. He believed that if management could codify production knowledge into rules, then they could deliberately develop workers through training programs.[9] Although his ideas were controversial among unions and workers, Taylor's 1911 book, *The Principles of Scientific Management,* had a significant impact on industry and the organizational research that followed.

Organizational design theorists also drew from the studies of the sociologist Max Weber. Informed by his study of industrialization's effects on society, his theory of bureaucracy emphasized the emergence of merit-based bureaucratic authority justified by laws and norms. Theorist Mary Jo Hatch notes that Weber's bureaucracy aimed to "rationalize the social order in a manner similar to technology's rationalizing influence on the economic order."[10] She states that because decisions of management and workers were made rationally and fairly, bureaucracy was considered superior to authoritarian or charismatic leader models.[11] Thus, rationally justified authority is a critical component of a successful organizational structure.

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[8] Adam Smith, "Of the Division of Labor," in *Classics of Organization Theory*, 4th ed., ed. Jay M. Shafritz and J. Steven Ott (Forth Worth: Harcourt Brace College Publishers, 1996), 40-45.

[9] Frederick Winslow Taylor, "The Principles of Scientific Management," in *Classics of Organization Theory*, 4th ed., ed. Jay M. Shafritz and J. Steven Ott (Forth Worth: Harcourt Brace College Publishers, 1996), 66-79.

[10] Mary Jo Hatch with Ann L. Cunliffe, *Organization Theory: Modern, Symbolic, and Postmodern Perspectives* (Oxford: Oxford University Press, 2006), 31.

[11] Hatch, *Organization Theory*, 31.

The three main aspects of bureaucracy, as described by Weber, are division of labor, the hierarchy of authority, and formalized rules and procedures.[12] Leveraging the efficiency of division of labor, bureaucratic organizations divide jobs into departments with specific roles or functions. These departments are organized hierarchically with distributed authority and formal reporting relationships. This structure defines communication channels that connect individuals both upward to the top authority and downward to subordinates. The top official, appointed by a superior authority, holds a vocation, loyal to impersonal and functional purposes.[13] Finally, organizational activities are governed by explicit rules, policies, and procedures to ensure a stable working environment.

While many theorists viewed bureaucratic structure as superior over other management models of the era, it was not without its faults. In large industrial organizations with stable environments, bureaucracy can provide the efficiencies of specialization, clear lines of communication, and transparent standards. Yet, strict adherence to standards can stifle innovation and create a monotonous working environment. Furthermore, not all organizations exist in a stable environment. Acknowledgment of these shortcomings led to the development of the neoclassical and modern organizational thought.

Neoclassical Theory

Neoclassical organizational theory grew in response to gaps in classical theory. Writing primarily in the years following World War II, neoclassical theorists responded to the lack of humanness in the formalized rules and hierarchical structure embraced by classic thinkers.[14] Philip Selznick argued that a singular focus on structural efficiency was ill-equipped to address the competing interests of individuals within an organization. Rather than an efficiency-based structure, Chester Barnard advocated a moral code and sense of purpose to hold the organization

[12] Hatch, *Organization Theory*, 103.

[13] Max Weber, "Bureaucracy," in *Classics of Organization Theory*, 4th ed., ed. Jay M. Shafritz and J. Steven Ott (Forth Worth: Harcourt Brace College Publishers, 1996), 82.

[14] Shafritz and Ott, *Classics of Organization Theory*, 96.

together. Meanwhile, Herbert Simon proposed that decision-making and organizational dynamics played the most important role in maximizing efficiency. Through expanding the scope of design theory beyond structure and processes, these writers furthered the field of organizational study.

Modern Theory

Also referred to as "structural contingency theory," modern thought of the 1960s and 1970s challenged the classic assumption that there was "one best way" to organize. Contingency theorists argued alternatively that there exists a best structure for achieving an organization's purpose in given environmental conditions. Turning away from the neoclassical focus on the human element, modernists believed "most problems in an organization result from structural flaws and can be solved by changing the structure."[15]

Tom Burns and George M. Stalker provide the archetypical theory in this domain. In their 1961 book *The Management of Innovation*, Burns and Stalker used qualitative case studies to conclude that mechanistic structures perform best in stable environments while organic structures are best for more uncertain settings.[16] Mechanistic organizations rely on specialized differentiation of functional tasks with precise methods for accomplishing each role. Supervisors guide behavior and control communication through well-established hierarchy. Loyalty and obedience are vital for the machine to function. In contrast, organic organizations favor a continual adjustment of tasks in order to adapt to the context. Authority and communication are networked and typically involve advice rather than strict direction. In organic organizations, a commitment to progress in the organization's goals is valued more than loyalty and obedience.[17] Burns and Stalker reasoned that innovation is typically limited in mechanistic organizations because high levels of hierarchy and centralized decision making stifle creativity and flexibility. However, in rapidly changing environments, innovation is necessary to respond to change and

[15] Shafritz and Ott, *Classics of Organization Theory*, 204.

[16] Tom Burns and G. M. Stalker, "Mechanistic and Organic Systems," in *Classics of Organization Theory*, 4th ed., ed. Jay M. Shafritz and J. Steven Ott (Forth Worth: Harcourt Brace College Publishers, 1996), 209-210.

[17] Burns and Stalker, "Mechanistic and Organic Systems," 209-210.

survive. In organic organizations, the informal, decentralized structure allows employees more freedom and flexibility to solve problems innovatively and adapt to changing circumstances.[18] Thus, matching organizational structure to the environment is a critical leadership task. This approach is the foundation of many contemporary organization theories.

The assertion that structure must be optimally designed for the environment assumes the conscious effort of leaders to rationally choose it. However, critics argue there are limits to managers' ability to employ the structural contingency approach. In attempting to choose and implement an appropriate design structure, leaders face challenges of managing complexity and culture. In larger, more complex organizations, the environmental variables present are often unknown or too numerous to manage. Further, even when a design is rationally selected, changing the culture of the individuals that comprise the organization may present an obstacle. Later theorists expanded organizational theory in these two dimensions, discussed below as systems and cultural theories.

Systems Theories

Acknowledging the complexity of social organizations, theorists turned to systems thinking to gain greater understanding of the behavior of organizations. Inspired by Ludwig von Bertalanffy's general systems theory, researchers attempted to identify interconnections and cause-and-effect relationships between elements in organizations. Conceiving of organizations as systems with inputs, outputs, processes, and feedback loops allowed systems theorists to better understand environmental impacts and enabled a more dynamic and adaptive approach.

In 1961, William G. Scott advanced that systems thinking is the best way to understand modern organizations. He broke down organizations into interdependent parts linked by processes of interaction. Through this lens, Scott recognized the psychological, social, and physiological characteristics of individuals must be considered when organizing work because

[18] Burns and Stalker, "Mechanistic and Organic Systems," 210.

human interactions affect the functioning of the formal structure. He concluded that tools of analysis and a unique conceptual framework must be developed to further advance the field.[19]

Continuing to develop the systems concept, Daniel Katz and Robert L. Kahn criticized classic organization models for defining boundaries and behaviors too narrowly. By focusing only on formal structure as a driver of production efficiency, these researchers perceived the organization as a closed system. Instead, Katz and Kahn argued, organizations are "flagrantly open systems" that interact continuously with the environment.[20] They reasoned that organizational activities consist of more than production tasks. As an organization develops, it interacts with its environment through support, maintenance, and adaptation activities that advance the survival of the system.[21] Although they fault classic models for ignoring environmental factors, Katz and Kahn laid the groundwork for merging the various schools of organizational thought.

Seeking to apply systems thinking to the management of organizations, James D. Thompson attempted to reconcile the simplicity of closed systems with the perceived complexity of open systems. He argued that a closed system allows for rational thinking focused on efficiency or control while an open system must account for uncertain environmental influences that cannot be predicted. Finding value in both models, Thompson asserted that a synthesis of the two approaches is necessary to best manage an organization. At the ground level of production, rational models of efficiency are possible. However, at the management level, environmental factors carry more weight. Because it is difficult to simultaneously manage rationality of production and indeterminateness of environmental factors, he suggested creating a separate part

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[19] William G. Scott, "Organization Theory: An Overview and an Appraisal," in *Classics of Organization Theory*, 4th ed., ed. Jay M. Shafritz and J. Steven Ott (Forth Worth: Harcourt Brace College Publishers: 1996), 264-273.

[20] Daniel Katz and Robert L. Kahn, "Organizations and the System Concept," in *Classics of Organization Theory*, 4th ed., ed. Jay M. Shafritz and J. Steven Ott (Forth Worth: Harcourt Brace College Publishers: 1996), 276.

[21] Hatch, *Organization Theory*, 121-122.

of the organization to manage uncertainty.[22] By embracing the importance of both formal structure in production and environmental factors in management, Thompson successfully linked classic and structural contingency theories and paved the way for contemporary ones.

Cultural Theories

While systems theorists attempted to account for environmental factors in rational design, organizational researchers of the 1980s and 1990s questioned the validity of structural theories altogether. Emphasizing the cognitive limitations of decision makers, writers during this period argued that culture was the dominant force in organizational behavior. Researchers in this discipline explored the ways social factors such as distribution of power, uncertainty avoidance, individualism, feminism, and time orientation affected the behavior of organizations.[23] Rather than relying on quantitative methods, cultural theorists believed qualitative means were more effective for analysis. By acknowledging the impact of culture on the organization, these theorists sought to understand the social drivers behind cultural behavior and to develop tactics to realize changes when necessary.

In his 1985 book *Organizational Culture and Leadership*, Edgar H. Schein identified culture as the cause of organizational behavior that could not be explained through rational models. Influenced by social constructivism, his definition of organizational culture helped articulate how it was formed and pointed to approaches to changing it. According to Schein, culture is:

> the pattern of basic assumptions that a given group has invented, discovered, or developed in learning to cope with its problems of external adaptation and internal integration, and that have worked well enough to be considered valid, and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to these problems.[24]

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[22] James D. Thompson, "Organizations in Action: Social Science Bases of Administration Theory," in *Classics of Organization Theory*, 4th ed., ed. Jay M. Shafritz and J. Steven Ott (Forth Worth: Harcourt Brace College Publishers: 1996), 287.

[23] Hatch, *Organization Theory*, 181-185.

[24] Edgar H. Schein, *Organizational Culture and Leadership* (San Francisco: Jossey-Bass, 1985), 6.

Expanding on this definition, Schein identified three levels of culture in organizations: artifacts, values, and basic assumptions. Artifacts are the most visible elements of a culture, including physical space, language, art, and overt behavior. Values reflect beliefs of what ought to be. Although espoused values may not coincide with behavior, values that are validated through experience will eventually become assumptions. Basic underlying assumptions are beliefs that are taken for granted and are, therefore, nonconfrontable and nondebatable. This level of culture is the most difficult to observe and the hardest to change.[25] By understanding the depth of cultural factors in organizational behavior, leaders can then begin to develop strategies for transforming the culture.

Further developing Schein's premise, Harrison M. Trice and Janice M. Beyer acknowledged the challenges of changing culture and provided a framework for its analysis. Proposing that incremental change in culture happens naturally as a response to the environment, they defined cultural change as a planned, substantial break with the past. In this construct, change is typically made necessary by a disruptive event, requiring elements of both creation (of new culture) and destruction (of the old). Trice and Beyer divided change into categories and dimensions that inform leadership strategies for change. Notably, they suggested that when a change involves a high degree of innovation, an entirely new culture may be required for the organization to adopt the change.[26] The challenge of overcoming the resistance to change associated with disruptive innovation has become a salient topic in contemporary organizational theory.

Organizing for Innovation

Having reviewed significant modes of thought in organization theory more broadly, this section explores a theory that consolidates elements of all categories to address the particular task

[25] Schein, *Organizational Culture and Leadership*, 9-14.

[26] Harrison M. Trice and Janice M. Beyer, "Changing Organizational Cultures," in *Classics of Organization Theory*, 4th ed., ed. Jay M. Shafritz and J. Steven Ott (Forth Worth: Harcourt Brace College Publishers: 1996), 473-477.

of fostering disruptive innovation in organizations in a competitive environment. Classic theories provide a model for maintaining efficiency in the day-to-day execution of an organization's mission. Neoclassic approaches remind leaders of the need for a clear vision in managing the human element. Modern theories advise accounting for context in design structure. Systems theories acknowledge that different parts of the organization can serve different functions. Finally, cultural theories contribute that a separate organizational element may be necessary to overcome cultural obstacles. Embracing the roles that structure, culture, leadership, and external factors play in enabling an organization to achieve its goals, this monograph contends that the ambidextrous design proposed by Michael Tushman and Charles O'Reilly best enables large bureaucracies like the DoD to adapt to an environment of rapid technological development by adopting innovative advancements that help them maintain the competitive edge.

One significant obstacle leaders must overcome in adopting innovation is cultural resistance to change when the status quo is challenged. Observing the "tyranny of success," Tushman and O'Reilly proposed several reasons that managers ignore breakthrough technological innovation to their detriment. First, because an organization's culture is built on successful practices, innovation that threatens these practices may be viewed as deviant. Second, if no pressing problem exists, members of the organization do not see any reason to change, particularly if the innovation brings into question their relevance. Third, technical experts are often removed from the end user of their products and fail to see how the environment has changed.[27] Due to these factors, successful organizations often seek to preserve their core competencies, even when their survival depends on their ability to adapt.

To manage the pitfalls of uncertainty, Tushman and O'Reilly propose that leaders must "manage for today and for tomorrow simultaneously."[28] They must compete in the short term by

[27] Michael L. Tushman and Charles A. O'Reilly III, *Winning through Innovation: A Practical Guide to Leading Organizational Change and Renewal* (Boston: Harvard Business School Press, 1997), 7-8.

[28] Tushman and O'Reilly, *Winning through Innovation*, 3.

developing strategy, structure, culture, and processes that incrementally improve upon their current successes while at the same time mastering when to embrace disruptive change to ensure long-term survival. This requires not only a leader with both clarity of vision and the ability to shape culture, but also an organizational structure to support these diverging objectives.

Seeking to identify the most appropriate structure for harnessing both incremental and disruptive innovation, Tushman and his colleagues conducted an empirical study of four prevailing designs found in industry. They compared functional, cross-functional, spinout (completely separate entity), and ambidextrous organizations to determine relatively which was the most effective at generating and adopting innovations. Although the study used a limited sample of thirteen select businesses, the results carry weight because the size and nature of the entities are comparable to the DoD. Tushman et al. revealed that senior team integration and structural differentiation (physical separation of the innovation unit from the rest of the organization) make a clear difference when organizing for innovation.[29] The ambidextrous design proved to be relatively more effective than others.

Tushman and O'Reilly define ambidextrous organizations as ones that "celebrate stability and incremental change as well as experimentation and discontinuous change simultaneously."[30] To do this, organizations must embrace internally inconsistent competencies, structures, and cultures under a single vision. For example, a large bureaucracy with mechanistic structures and conservative culture could also contain a division with organic structures and innovative mindset. The critical factors with this model include structural differentiation, targeted structural integration (links from the innovation unit to critical functions of the parent unit), and strong support from senior leaders.[31] Thus, by choosing an organizational design that supports multiple

[29] Michael Tushman, Wendy K. Smith, Robert Chapman Wood, George Westerman, and Charles O'Reilly, "Organizational Designs and Innovation Streams," *Industrial and Corporate Change* 19, no. 5 (June 2010): 1355, accessed August 15, 2019, https://doi.org/10.1093/icc/dtq040.

[30] Tushman and O'Reilly, *Winning through Innovation*, 14.

[31] Tushman et al., "Organizational Designs and Innovation Streams," 1356.

cultures, leaders can maximize current competencies while hedging against uncertainties in the environment.

Relevant Conclusions

Tushman and O'Reilly's definition of ambidextrous organizations provides four criteria that will be used to identify the structure in the DoD's attempts at organizing for innovation. First, the organization must possess two separate structures within it: a mechanistic bureaucracy to manage stability and an antithetical sub-organization with organic characteristics to handle uncertainty. Second, these structures must be united by a common vision of success for the organization. Third, the innovative sub-organization must have direct access to senior leaders with the power to implement their breakthroughs. Finally, the sub-organization must have a separate physical space in which to innovate. These criteria are used in analysis of historical case studies as well as current initiatives.

In the next section, this monograph will explore two organizations that have proven records of accomplishment in harnessing technological innovation for the DoD. It will examine the successful efforts of DARPA and Skunk Works to rapidly bring technological innovation to the warfighter with a particular focus on their organizational structure and other factors that enabled their success. Through the lessons learned from organization theory research combined with real-world experience, the paper will analyze whether new organizations generated by the DoD have the potential to operationalize today's innovative technologies.

Innovation in Action

Theory suggesting ambidextrous organizations are best poised to harness disruptive innovation is consistent with the actual structures of organizations the DoD has historically turned to in times of technological crisis. Although clearly a large bureaucracy, the DoD has repeatedly demonstrated its ability to rapidly operationalize breakthrough commercial technology when national security is at stake. One of the ways it has done so is through leveraging creative

organizational constructs both in the defense industry and within the DoD. Lockheed's Skunk Works and the Defense Advanced Research Projects Agency (DARPA) are two of the most successful examples of organizations that enabled the DoD to maintain its competitive edge. While the success of research and development (R&D) organizations can be measured in a variety of ways, this monograph defines success as the direct transfer of innovative technology to the DoD for use by the warfighter. Examining the formal organizational structure of these two organizations reveals not only their ambidextrous nature, but also the additional informal factors necessary for their success within the particular bureaucratic environment of the US government.

Skunk Works

In 1943, Germany became the first nation to successfully field jet fighters, surprising Allied forces in the skies of Europe. These state-of-the art aircraft could fly faster and higher than the propeller-driven Allied fighters. Faced with the prospect of entering a war in which its airpower was outmatched, the US War Department asked Lockheed Corporation to design a prototype that could compete with this new development. The company was given 180 days to build a jet that could fly 600 mph, a full 200 mph faster than their top-performing airframe, the P-38 Lightning.[32]

To meet the challenge of this high-priority, time-critical project, chief engineer Clarence "Kelly" Johnson assembled a select group of twenty-three design engineers and thirty shop mechanics and set up a secretive project in a circus tent apart from the main factory. Because he enjoyed the trust of the Chief Executive Officer (CEO), Kelly was given complete autonomy over this project. Acting outside of the normal processes of the company, he imbued his workers with his ten basic rules of operation. The message was clear: "Everything possible will be done to

[32] Ben R. Rich and Leo Janos, *Skunk Works: A Personal Memoir of My Years at Lockheed* (Boston: Little, Brown, and Company, 1994), 111.

save time."[33] The group's alternative structure within Lockheed, along with Kelly's vision, direct access to the CEO, and their physical location fits the criteria of the ambidextrous model.

The band of young and high-spirited workers quickly embraced this new culture and soon adopted a name for their unique operation. A nearby plastics factory infused their circus tent with a noxious odor. The workers often joked about the problem and one day even answered the phone by saying "skonk works," inspired by a smelly concoction in the "L'il Abner" comic strip. Kelly initially rejected the name, pretending to fire the engineer who said it, but it stuck instantly with the workers. Later, cartoonist Al Capp objected to the use of his term, so Lockheed officially trademarked this division Skunk Works, a name that would become synonymous with innovative design.[34]

Kelly's creative team not only met the challenge of producing the jet fighter prototype, but also set the standard for innovative projects to follow. They produced the P-80 Shooting Star in only 143 days. Although World War II ended before the aircraft could be used operationally, the P-80 was mass-produced and became the first US jet fighter used in war over the skies of Korea. Building on this achievement, the Skunk Works model would continue to meet national defense needs through development of the U-2, the SR-71, and the F-117.

Significant Innovations

As the Korean War ended, President Eisenhower's focus shifted to addressing the Cold War intelligence gaps that were the source of much anxiety for the country. To reduce uncertainty about Soviet capabilities, the Central Intelligence Agency (CIA) charged Lockheed with building a high-altitude spy plane. Skunk Works answered the call with the U-2 Dragon Lady, an aircraft that could fly at 70,000 feet, above the reach of Soviet fighters and missile defense of the era. The photographs provided by the U-2 eased concerns that the Soviets outnumbered the United States in bomber aircraft, tracked progress of nuclear programs, and would later provide crucial

[33] Rich and Janos, *Skunk Works*, 116.
[34] Rich and Janos, *Skunk Works*, 112.

intelligence about Soviet actions in Cuba.[35] Unfortunately, the aircraft was not beyond the reach of Soviet radar systems as each flight was tracked intently by the Soviets. The necessity to defeat Soviet radar would drive future Skunk Works efforts.

Almost immediately after the first U-2 reconnaissance flights over Russia, Kelly directed Skunk Works to begin working on a replacement that could fly faster and higher. It was only a matter of time before the Russians would develop missiles to shoot down the U-2 and Kelly wanted to have a solution ready. He demanded a plane that could fly at 90,000 feet at Mach 3, sixty percent faster than Lockheed's fastest jet.[36] To overcome the challenges due to the heat produced at that speed, as well as the air density at that altitude, required a radical departure from contemporary design. Almost every component had to be uniquely designed for the prototype. Yet, even though the design performed at revolutionary speeds and heights, President Eisenhower stipulated the need to reduce the size of the aircraft on enemy radar. This presidential imperative led to another innovation: the use of radar-absorbing composites. After managing to lower the cross-section by ninety percent, Lockheed was finally funded by the CIA to build the aircraft. Although final acquisition by the DoD would be complicated by a change of administration, the SR-71 Blackbird was an unprecedented leap in technology and would serve the nation for thirty years without losing a single aircraft to enemy fire or accident.[37]

As the Russians began to export their air defense systems to clients around the world, the Pentagon increased its demand for technology that could defeat these radar-guided threats. The DoD was particularly concerned by the performance of American-built Israeli fighters against Soviet systems in the 1973 Yom Kippur War.[38] In 1975, just as Kelly Johnson had retired and Ben Rich had taken the reins of Skunk Works, the DoD hosted a competition to find an aircraft with the lowest radar signature. As luck would have it, one of the Skunk Works' young engineers

[35] Rich and Janos, *Skunk Works*, 148-9.
[36] Rich and Janos, *Skunk Works*, 193.
[37] Rich and Janos, *Skunk Works*, 241.
[38] Rich and Janos, *Skunk Works*, 17.

had recently discovered precise formulas for calculating an aircraft's radar cross-section. As a result, he was able to design an aircraft one thousand times less visible than Lockheed had ever designed.[39] Even for an organization as innovative as Skunk Works, this concept was radical and met with resistance. Yet with Rich's unwavering support, the project won the competition and the Air Force purchased the aircraft even before an initial test flight. The F-117 Nighthawk would prove its incredible worth over the night skies of Iraq during Desert Storm, achieving a seventy-five percent direct-hit rate while taking zero losses.[40]

Post-Cold War, Skunk Works would continue to lead the way in successfully fielding innovative technology. Although modern defense projects have involved teams comprised of several corporations, Lockheed played a critical role in the development of both fifth generation fighter aircraft, the F-35 Lightning II and the F-22 Raptor. Thus far, they have won eight Collier Trophies for "the greatest achievement in aeronautics or astronautics in America, with respect to improving the performance, efficiency, and safety of air or space vehicles, the value of which has been thoroughly demonstrated by actual use during the preceding year."[41] Currently, Skunk Works is pursuing research on next-generation fighters, unmanned systems, hypersonics, quiet supersonics, sustainable energy, and resilient networks to enable multi-domain operations. Their unrelenting focus on disruptive technology should enable the DoD to keep abreast of technological change for years to come.

Although Skunk Works has achieved many astonishing breakthroughs, not every project ended in success. One notable example of failure was its attempt to build a hydrogen-powered plane in 1956. Despite extensive testing and development of safety processes for handling highly-volatile liquid hydrogen, Skunk Works could not achieve the desired range of flight nor resolve the complicated logistics involved in operationalizing this type of aircraft. After spending

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[39] Rich and Janos, *Skunk Works,* 26.
[40] Rich and Janos, *Skunk Works,* 104.
[41] "Collier Trophies," Lockheed Martin, accessed December 15, 2019, https://www.lockheedmartin.com/en-us/who-we-are/business-areas/aeronautics/skunkworks/collier-trophies.html.

$6 million on development, it returned $90 million to the US Air Force, cancelling the contract.[42] Failures of this kind are part of the risk-tolerant model that Skunk Works espouses. By experimenting at small scale, the risks remained small in comparison to the large-scale projects produced by the main plant. Further, Skunk Works learned from its failures and shared some of these lessons with industry partners. Lockheed considers Skunk Works' ability to fail small and take risk to be an important factor to their success: "The bottom line is we aren't afraid of failure. We know you can't you push the boundaries of what's possible without getting outside the comfort zone. Sometimes that means making mistakes, but from those mistakes, we learn how to be better."[43]

Organizational Factors of Success

Skunk Works' experiences in operationalizing disruptive technology suggest several factors that enable its organizational design to achieve success. First, although the innovation entity requires resources from the parent company to maintain low overhead, it should be insulated from the oversight of top management. Second, the entity should have highly motivated workers, including a strong top-level leader to act as champion. Third, the project should have specific objectives to achieve. Lastly, a strategy should exist to transfer the technology to the client, in this case DoD. These experiential lessons are consistent with Tushman and O'Reillys's organizational design research and support the value of ambidextrous structures.

The first factor reinforces the theoretical value of a small innovative unit within a larger bureaucracy, if it is given the freedom to operate autonomously. Former head of Skunk Works Ben Rich observes that the division was able to maintain low overhead and acceptable risk because of its existence within Lockheed. He states, "in today's austere business climate I don't think a Skunk Works would be feasible if it could not rely on the resources of the parent entity to

[42] Rich and Janos, *Skunk Works*, 177.

[43] "Rapid Prototyping," Lockheed Martin, accessed December 15, 2019, https://www.lockheedmartin.com/en-us/who-we-are/business-areas/aeronautics/skunkworks.html#rapidprototypingareas/aeronautics/skunkworks.html#rapidprototyping.

supply the facilities, tools, and workers for a particular project and then return them to the main plant when the task is completed."[44] Part of the savings results from not having to reinvent the wheel for each prototype. Skunk Works recognizes the benefits of using existing aircraft structures and parts when creating a new project. Recently, it achieved a ninety percent reduction in parts and fifty percent reduction in costs by modifying an existing structure for a new prototype rather than starting from scratch.[45] Time and cost savings like this demonstrate the benefits of remaining part of a larger bureaucracy. However, while providing support, the top management must allow the division the freedom to work outside of bureaucratic processes.

In an article for *Research Technology Management*, Peter Gwynne states that for large, high-technology companies to succeed with a skunkworks model, "the corporate culture must be appropriate to support a countercultural entity in its midst" and must "insulate its personnel from day-to-day corporate activities."[46] This is consistent with Ben Rich's belief that top management must surrender oversight by granting full autonomy to the innovating entity. He proclaimed that Lockheed "encouraged our people to work imaginatively, to improvise and try unconventional approaches to problem solving, and then got out of their way."[47] Both Rich and Gwynne emphasize that a rigid bureaucracy must give their innovation divisions the flexibility to succeed. This implies both the formal structure of an ambidextrous organization capable of tolerating internally inconsistent competencies, structures, and cultures under a single vision as well as an informal culture that enables it.

The second factor addresses the leadership and personnel required to maintain a corporate culture of innovation. Clearly, innovation requires motivated individuals with groundbreaking ideas, but Gwynne emphasizes the need for a high-level champion to advocate for their creative

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[44] Rich and Janos, *Skunk Works*, 318-9.

[45] "Rapid Prototyping," Lockheed Martin, accessed December 15, 2019, https://www.lockheedmartin.com/en-us/who-we-are/business-areas/aeronautics/skunkworks.html#rapidprototyping.

[46] Peter Gwynne, "Skunk Works, 1990s Style," *Research Technology Management* 40, no. 4 (July 1997): 18.

[47] Rich and Janos, *Skunk Works*, 338.

research and to shield them from interference.[48] Rich agrees that strong leadership is critically important, but acknowledges that it is rare. "There are very few strong-willed individualists in the top echelons of big business — executives willing or able to decree the start of a new product line by sheer force of personal conviction, or willing to risk investment in unproven technologies."[49] For Skunk Works, Kelly Johnson and Ben Rich both provided the resolute leadership to foster and protect the revolutionary ideas of their team. Once again, this observation is supported by Tushman and O'Reilly's empirical study, which found organizations to be most effective at innovation when they had strong support from an ambidextrous manager who was closely integrated with senior management.[50]

The third factor is demonstrated by the vision provided by Johnson and Rich. Skunk Works leaders were largely successful when they provided clear-cut goals for their teams to execute. Ben Rich believed these "extremely difficult but specific objectives" were at the heart of the Skunk Works model.[51] These objectives were frequently based on critical technology gaps affecting US national security. From the demand for a fighter jet that could outpace the Luftwaffe, to the call for a stealth fighter that could defeat Soviet radar, Rich felt Skunk Works engineers worked best when they were given a challenging but clear-cut design goal. Those goals, combined with the urgency of a national threat provided a motivating purpose that inspired success.

Finally, building on the previous factors, the strong leader's vision must include a strategy for transferring the disruptive innovation project to the client. Skunk Works leaders benefitted from a trusting relationship with the DoD in which they were given insight into top priority defense challenges. They enjoyed access to general officers and built relationships with service chiefs. Yet, because of the secret nature of most Skunk Works projects, they had to

[48] Gwynne, "Skunk Works, 1990s Style," 24.
[49] Rich and Janos, *Skunk Works*, 317.
[50] Tushman et al., "Organizational Designs and Innovation Streams," 1355-6.
[51] Rich and Janos, *Skunk Works*, 318.

remain vigilant for opportunities. Indeed, Lockheed was not even originally invited to the stealth competition because its work for the CIA was unknown to the acquisitions officers hosting the event. Because of its strong connections and relationships, it was able to secure its participation and win the contract. However, the transfer strategy is more than just gaining access to decision makers. It requires knowledge of the acquisition processes and regulations of the organization. Having experienced an exponential increase in the DoD's bureaucratic processes, Ben Rich expressed his concern about Skunk Works' future ability to produce results. Quipping that acquisitions regulations "could fill an entire shelf of 300-page books, in addition to 50,000 individual specifications, 12,000 contract clauses for specific components, 1,200 department directives, and 500 separate procurement regulations," Rich estimated that only forty-five percent of a product's budget actually is spent on producing the hardware while the rest is spent on red tape.[52] The relevance of these claims today will be explored in the next section.

In 2018, Lockheed's contributions to national security were recognized by congressional resolution as the standard for "super-secret, high priority, rapid execution projects performed on a minimal budget."[53] As an early example of the power of an ambidextrous organization, Lockheed's organizational design has been the archetype for innovation in corporations and government alike. The Skunk Works model has been imitated by Ford, McDonnell Douglas, and Xerox, among others, in their attempts to harness disruptive innovation in their organizations. The next section will address the way a countercultural entity within the DoD repeated industry's successes.

DARPA

On October 4, 1957, the Soviets launched Sputnik I, quickly followed by Sputnik II one month later. Although the Naval Research Lab and the Army Ballistic Missile Agency were both

[52] Rich and Janos, *Skunk Works*, 328-9.

[53] US Congress, Commemorating the 75th Anniversary of Lockheed Martin Skunk Works and the Significant Contributions of the Skunk Works to the National Security of the United States, S. Res. 39, 115th Cong., 2d sess. (June 11, 2018), 1.

pursuing satellite technology for the United States, the advanced development of the Russian program caught the nation off guard. Perceiving the services to be "idea-resistant, bureaucratic, wasteful, parochial, and basically incapable of 'moving out,'" President Eisenhower sought an organizational solution in response to this strategic surprise.[54] He created a position for a presidential science advisor as well as the President's Science Advisory Committee (PSAC) to keep him personally advised on scientific matters. Secretary of Defense (SecDef) Neil McElroy followed suit by establishing the Advanced Research Projects Agency (ARPA) on February 7, 1958 to pursue high priority R&D for the DoD.[55] The name was later changed to DARPA to reflect a focus on defense-related research, thus this monograph will use the current acronym to refer to the organization throughout.

From the start, DARPA was created as an antithetical organizational structure within the DoD. While the services were bureaucratic by design in order to promote standardization and continuity within a large organization, DARPA was created to be small, agile, and free from bureaucracy, reporting directly to the SecDef and responding to presidential priorities. Because McElroy used the agency as a top-down mechanism to force service decisions rather than allow services make decisions themselves, it met with understandable resistance.[56] Indeed, DARPA's mandate to research advanced concepts that were disruptive by definition would frequently put it at odds with the doctrinally bound services.

To resolve some of the services' concerns, DARPA was built with several stipulations for its operation. The organization would limit its influence by remaining small, consisting of 120 project managers on average. Rather than creating its own competing laboratories, it would oversee projects with commercial laboratories, industry, and universities. Finally, it would keep

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[54] Richard J. Barber Associates, Inc., *The Advanced Research Projects Agency, 1958-1974* (Washington DC: Richard J. Barber Associates, Inc., 1975), I-29.

[55] US Department of Defense, Directive 5105.15, "Department of Defense Advanced Research Projects Agency" (Washington, DC, February 7, 1958).

[56] Barber, *The Advanced Research Projects Agency*, I-7.

the services involved by contracting through them and having service members on their staff.[57] This operational arrangement made DARPA more palatable to the services moving forward.

Modus operandi established, DARPA quickly built a culture of creativity based on four defining factors. First, the agency hires its program managers for short terms (three to five years) in order to promote a sense of urgency and attract workers motivated to achieve something, rather than just to build a career. Second, workers are instilled with the mission "to prevent and create technological surprise," linking this imperative with national security. Third, trust and autonomy are the cornerstones of the organization in its relationship with its workers. Finally, DARPA acknowledges that the revolutionary innovation that it seeks requires risk-taking and tolerance of failure. This culture enables their "change the world" philosophy as they focus on transformative innovation.[58]

Existing within the DoD, DARPA's structure meets the criteria of an ambidextrous sub-organization. While its program managers are organized in an organic, flexible design and its culture is counter to that of the DoD, DARPA's vision is aligned with the overarching DoD vision to protect national security. Its leadership reports directly to top-level Pentagon officials, allowing for access and advocacy of its programs. Finally, since programs are contracted to outside agencies, the organization achieves physical separation from the parent organization.

Significant Innovations

In DARPA's six-decade existence, it has successfully transferred a large number of revolutionary capabilities to the services. The type of innovation it produced has depended significantly on US policy and events.[59] Based on these events, the organization's history can be broken down into five periods: its formative years, the Vietnam War era, the Revolution in

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[57] Barber, *The Advanced Research Projects Agency*, I-7.

[58] "Innovation at DARPA," DARPA, July 2016, accessed December 17, 2019, https://www.darpa.mil/attachments/DARPA_Innovation_2016.pdf.

[59] Institute for Defense Analyses, *DARPA Technical Accomplishments: An Overall Perspective and Assessment of the Technical Accomplishments of the Defense Advance Research Projects Agency: 1958-1990*, vol. 3, by Richard H. Van Atta, Seymour J. Deitchman, and Sidney G. Reed (Alexandria, VA, July 1991), III-1.

Military Affairs (RMA) era, the post-Cold War era, and the current era of great power competition.

DARPA spent its formative years focused primarily on presidential priorities. One of its first tasks was to help President Eisenhower gain an accurate assessment of Soviet capabilities by developing the Corona reconnaissance satellite. First realizing success in 1960, the program provided valuable photos of Soviet territory throughout the Cold War.[60] Eisenhower also sought to make a ban on nuclear weapons testing enforceable. To this end, DARPA's project VELA developed satellite sensors that could detect nuclear explosions, enabling the 1963 Limited Nuclear Test Ban Treaty.[61] Concurrently pursued, the DEFENDER program addressed the need for ballistic missile defense. This technology suite included large ground-based phased array radars to detect and track multiple incoming objects, infrared satellite early warning systems, and high-energy lasers.[62] In addition to these high-impact programs, DARPA's TIROS weather satellite and TRANSIT navigation satellite programs provided unprecedented data to the government in support of national defense.

Although DARPA's early programs were primarily focused on space technology, this category of innovation was destined to be transferred to the National Aeronautics and Space Administration (NASA), forcing the agency to refocus its efforts. Its reorganization under the Director of Defense Research and Engineering (DDR&E), a change in presidential administration, and a smoldering war in Vietnam would shape the next decade of projects.

With the inauguration of President John F. Kennedy and his doctrine of "flexible response," DARPA's attention turned towards technology that would contribute to American success in the limited war in Vietnam. Operating alongside the Military Assistance Advisory

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[60] "Corona Reconnaissance Satellite," DARPA, accessed December 19, 2019, https://www.darpa.mil/about-us/timeline/corona-reconnaissance-satellite

[61] "VELA: Nuclear Explosion Detector," DARPA, accessed December 19, 2019, https://www.darpa.mil/about-us/timeline/vela.

[62] Institute for Defense Analyses, *DARPA Technical Accomplishments: An Historical Review of Selected DARPA projects*, vol. 1, by Richard H. Van Atta, Seymour J. Deitchman, and Sidney G. Reed (Alexandria, VA, February 1990), 6-1 - 8-13.

Group Vietnam (MAAG-V), DARPA set up a Combat Development Test Center in Saigon dubbed Project Agile. The research conducted by this group was much more tactical in nature, centered on the challenges of operating with partners in the jungle. Project Agile introduced silent swamp boats, gliders, tracking dogs, the AR-15 rifle, and the controversial Agent Orange into the theater.[63] DARPA also partnered with RAND Corporation to conduct behavioral science studies in an attempt to understand the motivations of the insurgency.

As American public opinion turned against the Vietnam war, DARPA, too, found itself increasingly unpopular. Research partnerships with universities became too controversial to continue and government agencies voiced multiple complaints. Congress and the services argued Project Agile was not advanced research, but "mission-oriented engineering" reserved for the services. The Senate accused DARPA of encroaching on the Department of State's work. Further, the agency's foray into behavioral science was seen as outside the realm of defense research, prompting the Mansfield amendment restricting military research to defense-related topics.[64] Despite the fact that research in this period also produced the ARPANET, the original internet, DARPA's reputation and budget suffered enormously, causing some decision-makers to suggest the agency had "outlived its usefulness."[65]

Under congressional scrutiny, DARPA reinvented itself in the wake of he Vietnam War. Spurred by new DDR&E and DARPA leadership, the agency established a long-term plan to defeat Soviet air defenses by harnessing advanced technology. The resulting Assault Breaker program would enable an offset strategy better known as the Revolution in Military Affairs.[66] Based on Albert Wohlstetter's "system of systems" approach, Assault Breaker integrated a number of technologies for synergistic effects. Skunk Works' stealth aircraft, precision guided

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[63] Annie Jacobsen, *The Pentagon's Brain: An Uncensored History of DARPA, America's Top Secret Military Research Agency* (New York: Little, Brown and Company, 2015), 120-26.

[64] Institute for Defense Analyses, *DARPA Technical Accomplishments*, vol. 3, II-11.

[65] Institute for Defense Analyses, *DARPA Technical Accomplishments*, vol. 3, II-10.

[66] Institute for Defense Analyses, *Transformation and Transition: DARPA's Role in Fostering an Emerging Revolution in Military Affairs*, vol. 1, by Richard H. Van Atta, Michael J. Lippitz, Jasper C. Lupo, Rob Mahoney, and Jack H. Nunn (Alexandria, VA, April 2003), S-1 - S-2.

munitions, stand-off weapons such as the Army Tactical Missile System (ATMS), and advanced intelligence, surveillance, and reconnaissance (ISR) systems utilized by Joint Surveillance Target Attack Radar System (JSTARS) aircraft combined to produce spectacular results on the battlefield.[67] The technological surprise DARPA's research enabled during Operation Desert Storm truly fulfilled the mission the agency was created to accomplish.

Having achieved overwhelming success in enabling RMA, DARPA found itself in the post-Cold War era without a defining strategy. The agency sensed it was "at the cusp of a another critical and fundamental period in defense research and development, in which the role of advanced technology is in question, as well as the areas of its application and the time horizon for its need."[68] The focus of DARPA's R&D returned to solving the problems of limited wars and the associated ISR demand. The agency's work on unmanned aerial vehicles (UAVs) led to the employment of the Predator UAV in Bosnia and later the Global Hawk.[69] After the attacks of September 11th, DARPA sought data mining solutions to the terrorist threat through the Total Information Awareness program, but once again found itself under congressional scrutiny for privacy concerns.[70] Additionally, the agency delved into biometrics and human behavior studies as the nation found itself in a counter-insurgency fight once more. Overall, this was a period of mixed results for DARPA.

With the 2018 National Defense Strategy emphasis on great power competition, the DoD and DARPA have shifted focus from incremental research to advanced disruptive technology. Today's research revolves around DDR&E priorities of artificial intelligence (AI), hypersonics,

[67] "Assault Breaker," DARPA, accessed December 20, 2019, https://www.darpa.mil/about-us/timeline/assault-breaker.

[68] Institute for Defense Analyses, *DARPA Technical Accomplishments*, vol. 3, III-7.

[69] "Predator," DARPA, accessed December 20, 2019, https://www.darpa.mil/about-us/timeline/predator.

[70] Congressional Research Service, *Privacy: Total Information Awareness Programs and Related Information Access, Collection, and Protection Laws*, by Gina Marie Stevens (Washington DC, March 21, 2003), summary.

space, autonomy, and cyber, among others.[71] Because information on the transfer of any of this research is designated as classified, this monograph is unable to analyze the success of modern programs.

Organizational Factors of Success

Because it is a counter-cultural entity with top-level integration within a larger bureaucracy, DARPA fits the definition of an ambidextrous organization. Similar to Skunk Works' structure, this organizational design has allowed a great deal of disruptive innovation to penetrate the bureaucracy of the parent organization. As a government agency, it benefits from a significant amount of publicly available analysis on the factors contributing to its success. Those reports substantiate the same four factors observed by evaluations of Skunk Works' success and add depth to analysis of the particular challenges of transferring new technology within the DoD.

First, DARPA's structure within the DoD provides resource benefits while insulating it from excessive oversight. Its 2019 budget of $3.4 billion is just half a percent of the overall $667.3 billion DoD appropriation, supplying ample funding for risk-taking while allowing the DoD to minimize overall risk.[72] Additionally, although its program objectives often flow from presidential or Office of the Secretary of Defense (OSD) imperatives, the agency is given full autonomy to pursue its research. The Institute for Defense Analyses (IDA) credits this extensive autonomy as a significant factor in DARPA's success.[73] Furthermore, the organization is given statutory authority to use "Other Transaction Agreements" (OTAs) that are "free of most of the acquisition statutes and regulations to which government agencies must typically adhere."[74] The use of this authority in particular insulates DARPA from bureaucratic red tape, enabling its freedom to innovate.

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[71] "Modernization Priorities," Undersecretary of Defense for Research and Engineering, accessed January 9, 2020, https://www.cto.mil/modernization-priorities/.

[72] "Budget," DARPA, accessed December 20, 2019, https://www.darpa.mil/about-us/budget.

[73] Institute for Defense Analyses, *DARPA Technical Accomplishments*, vol. 3, S-2.

[74] "Innovation at DARPA," DARPA, 19.

Second, DARPA benefits from highly motivated workers, and has been most successful when a strong DDR&E or OSD leader is its champion. As previously mentioned, the organization attributes its motivated workforce to its policy of limited tenure and high turnover. While the agency has consistently attracted good program managers, it also benefits from its ability to leverage the entire US technology community for its projects. Because DARPA can contract with industry, laboratories, and universities alike, it has the flexibility to seek out and contract with innovators across the nation, choosing those with the most potential. However, even with promising R&D, top-level advocacy is necessary to ensure the technology's adoption by the services. Truly revolutionary technology is often at odds with the services' requirements priorities, thus DDR&E or OSD leader intervention may be required to force the adoption of technological change. This proved to be the case with both stealth technology and UAV acquisition since the Air Force was hesitant to embrace these game-changing developments.[75]

Third, the IDA found that DARPA was most successful when there was a "clearly defined sense of mission and direction in the agency and DoD."[76] This is evidenced by the level of innovation achieved during each of the five periods discussed earlier in this section. When national strategic objectives were clearly communicated, DARPA tended to find innovative solutions. A second IDA report further supported this argument when analyzing DARPA's role in RMA. Based on interviews with DARPA's management, the study concluded that disruptive concepts achieved more progress when focused on "a small set of clear, high priority missions."[77] Thus, achieving competitive advantage and, conversely, avoiding technological surprise requires clear vision and direction from DoD leadership.

Lastly, DARPA's extensive experience developing strategies to transfer technology to the DoD provides the most instructive lessons. As mentioned previously, DARPA's aim to develop disruptive technology is fundamentally opposed to the services' aim to master existing core

[75] Institute for Defense Analyses, *Transformation and Transition*, S-3 - S-8.
[76] Institute for Defense Analyses, *DARPA Technical Accomplishments*, vol. 3, S-8.
[77] Institute for Defense Analyses, *Transformation and Transition*, S-10.

competencies and fulfill established capability requirements. In order to successfully cross the so-called "valley of death" from R&D to service acquisition, the transition must be well planned. Analysis points to three strategies for achieving success in this final obstacle: active collaboration with the service to obtain buy-in, OSD advocacy to force service acceptance, or deliberate pursuit of foundational research that enables the services to achieve innovations of their own design.

The ideal transition strategy is to seek service endorsement from the start. The IDA observed "in cases where programs were joint, and tightly coordinated with service interest . . . the ultimate outcome tended to be service assumption of responsibility for the completion of the program or use of its output in another program, because that was intended from the start."[78] This observation has remained consistent throughout the years. In 1985, the National Security Industrial Association (now National Defense Industrial Association) concluded that a close relationship between DARPA and the services throughout the lifecycle of a project is the "primary driver" of success in program transition.[79] This dynamic continued to remain true in 2015 when the US Government Accountability Office (GAO) listed "active collaboration with potential transition partners" as one of four primary factors in successful technology transition.[80]

When service endorsement is not achieved through collaboration, OSD advocacy provides a second strategy for transition. Because of the disruptive nature of advanced technology, DARPA's programs may directly compete with platforms in which the services have heavily invested. When OSD decision-makers are convinced of the value of the innovative technology, they may choose to override service budget decisions or allocate additional funding to support the adoption of the program. Indeed, this proved to be the case with UAV technology. Despite deficiencies noted in airborne ISR during Operation Desert Storm, service leaders

[78] Institute for Defense Analyses, *DARPA Technical Accomplishments*, vol. 3, V-9 - V-10.

[79] National Security Industrial Association, *The Defense Advanced Research Projects Agency's Technology Transfer Process: A Study* (Washington DC, December 1, 1985), 28.

[80] US Government Accountability Office (GAO), *Defense Advanced Research Projects Agency: Key Factors Drive Transition of Technologies, but Better Training and Data Dissemination Can Increase Success* (Washington DC, November 2015), 12.

continued to underinvest in UAV technology. OSD leadership decided that centralized control was necessary to accelerate development and funded the research that would eventually become the Predator and Global Hawk.[81] The efficacy of senior leader intervention in cases like this validates the necessity for top-level advocacy.

Finally, in times where no urgent national defense imperatives drive acquisition or budget constraints prevent transition, DARPA has found success in pursuing broadly applicable foundational research that underlies larger technology leaps. Although research areas like materials, microelectronics, and computing may not directly apply to military programs, these technologies underpin and enable military capabilities. For example, DARPA gains in computer processing speeds enabled the development of precision-guided munitions and other advanced weapon capabilities.[82] This type of basic tech exploration may lead to breakthroughs adopted by service R&D laboratories and eventual DoD acquisition.

Although existing literature suggests that DARPA has reflected rather deliberately on its transition strategies, the GAO has criticized the agency for not putting enough emphasis on the subject. According to a 2015 report, the GAO charged DARPA with prioritizing radical technology, treating transition of the resulting program as an afterthought. The report cites DARPA officials as relegating the responsibility of successful transition to the services.[83] The GAO strongly recommended additional acquisitions training for DARPA program managers and increased dissemination of technical data to the services, emphasizing that transition should be a natural extension of innovation. The DoD acknowledged the recommendations but countered that the short tenure of program managers does not allow for extensive training. Alternatively, DARPA employs a small Adaptive Execution Office (AEO) to provide transition expertise and track transition activity.[84]

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[81] Institute for Defense Analyses, *Transformation and Transition*, S-8.
[82] Institute for Defense Analyses, *DARPA Technical Accomplishments*, vol. 3, V-17.
[83] GAO, *Defense Advanced Research Projects Agency*, 18.
[84] "Innovation at DARPA," DARPA, 16.

Case Study Conclusions

The success of both Skunk Works and DARPA as ambidextrous organizations supports facets of organizational design theory and provides useful lessons for DoD decision-makers charged with organizing for innovation. Notably, the success of the organization's design depends significantly on senior leader vision and advocacy, as well as freedom from bureaucratic processes. Informed by these lessons, the next section will evaluate recent DoD organizational changes to predict the likelihood that they will answer the SecDef's call to organize for innovation.

DoD Organizational Changes and AFWERX

Based on lessons derived from both organizational design theory and real-world case studies, this section evaluates the appropriateness of recent DoD organizational changes, particularly the establishment of AFWERX. Since structural contingency theory contends that organizations must be appropriate for their environment, the first section will describe the strategic context that drove these changes. After examining today's defense environment, the monograph will then trace the origins of AFWERX and describe its mission and the tools employed to accomplish it. Finally, the section will close with analysis of whether AFWERX's creation is an appropriate response to the challenges faced by the DoD using organizational design theory and the four lessons learned from historical case studies. Because it responds to the strategic context, utilizes an ambidextrous structure, and builds upon historical lessons learned, the monograph concludes that AFWERX is indeed a well-adapted solution to the DoD's innovation challenges.

Strategic Context

Since many organizational design theorists advise that there is a best structure for given environmental conditions, it is important to understand the strategic environment in which modern initiatives were devised. Although the *2018 National Defense Strategy* directed the DoD

to organize for innovation, recent defense organizational changes did not begin there. The NDS mandate is part of a continuing effort to position the DoD for successful innovation that was renewed by Secretary of Defense Charles "Chuck" Hagel. Following the 2014 *Quadrennial Defense Review* in which he acknowledged a rapidly changing security environment and called for a rebalance of defense efforts in order to avoid erosion of high-end DoD combat power, Secretary Hagel published a memorandum announcing the Defense Innovation Initiative.[85] This initiative called for innovative solutions to maintain a competitive advantage over potential adversaries who had been modernizing and developing disruptive capabilities.[86] Designating the Deputy Secretary of Defense, Robert O. Work, to oversee the effort directly, Secretary Hagel called for a "third offset strategy that puts the competitive advantage firmly in the hands of American power projection over the coming decades."[87] Although Secretary Hagel left office three months later, Secretary Ashton Carter would continue this drive.

Under Secretary Carter, the DoD identified two changes in industry that created a gap in the military's ability to harness innovation. The first change involved the shift in balance of R&D spending. Throughout the Cold War, the DoD had led industry in R&D spending, accounting for forty percent of all US expenditures in 1987.[88] By 2013, commercial R&D investments had doubled while DoD spending remained static, resulting in the DoD accounting for less than twenty percent of research spending. This spending shift effectively gave industry the lead in innovation, letting commercial interests rather than DoD priorities drive R&D.

Even if DoD R&D spending increased proportionally, a second change in industry has made it difficult for the department to leverage commercial innovation. While industrial-age corporations pursued innovation by investing in their own research labs, information-age

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[85] US Department of Defense, *Quadrennial Defense Review 2014* (Washington, DC, 2014), iii-iv.

[86] US Department of Defense, "The Defense Innovation Initiative" (Washington, DC, November 15, 2014), 1.

[87] US Department of Defense, "The Defense Innovation Initiative," 2.

[88] US Government Accountability Office (GAO), *Military Acquisitions: DoD is Taking Steps to Address Challenges Faced by Certain Companies* (Washington DC, July 2017), 1.

companies like Google, Amazon, and Facebook employ a different model. Rather than research new concepts themselves, modern corporations simply acquire new capabilities through the purchase of small businesses and start-up companies, leaving the risk to venture capitalists.[89] As non-traditional entities not typically leveraged by the DoD, small businesses and start-ups face obstacles to entry in the defense market that prevent them from working with the department.

The GAO identified six challenges that deter non-traditional companies from partnering with the DoD: complexity of the process, unstable budget environment, long contracting timelines, intellectual property (IP) right concerns, government-specific terms, and an inexperienced DoD contracting workforce.[90] Companies interviewed by the GAO cited excessive costs associated with employing personnel to prepare DoD contract proposals and enforce regulations required by federal contracts. Further, the nature of start-ups does not allow them to wait the average thirteen months necessary to secure DoD contracts. Finally, even when a contract is secured, budget delays due to sequester or other congressional hang-ups can bankrupt these small businesses. Ultimately, interactions with the Defense Department were simply not incentivized for these highly innovative companies.

Having identified an acquisitions gap that was not adequately covered by pre-existing entities like DARPA, the DoD created an organization to promote outreach to non-traditional commercial innovators: Defense Innovation Unit-Experimental (DIUx). Setting up offices in Mountain View, Boston, and Austin, DIUx worked to improve access to, interaction with, and understanding of small businesses, entrepreneurs, and start-up companies. Empowered to approve and fund contracts in sixty days and use less-cumbersome OTAs, the DoD entity facilitated twenty-five arrangements in its first two years.[91] Through continued engagement, DIUx hopes to shape commercial R&D efforts to meet DoD needs. However, it may be the DoD

[89] Robert Hummel and Kathryn Schiller Wurster, "Department of Defense's Innovation Experiment" (June 30, 2016), accessed January 6, 2020, http://www.potomacinstitute.org/steps/featured- articles/83-department-of-defense-s-innovation-experiment.

[90] GAO, *Military Acquisitions*, 9.

[91] GAO, *Military Acquisitions*, 24.

that experiences the most transformation. Former DARPA program manager Dr. Robert Hummel states, "The reason the first DIUx office has been opened in Silicon Valley is not to change the ecosystem of the Valley, but rather to give DoD the opportunity to be educated by participants in the Valley about the realities of the marketplace."[92] Ultimately finding DIUx to be "a proven, valuable asset," Deputy Secretary of Defense Patrick Shanahan removed "experimental" from the organization's name in August 2018, giving DIU permanent status at the Pentagon.[93]

AFWERX

Given the successes achieved by leveraging DIU, the US Air Force (USAF) sought to create its own technology accelerator. The idea of capitalizing on less bureaucratic congressional authorizations to enable interactions with non-traditional partners was not entirely new to the service. Several directorates of Air Force Research Laboratory (AFRL) had been utilizing partnership intermediary agreements (PIA) since authorized by Congress in 1991. Through non-profit organizations such as the Wright Brothers Institute, the Griffiss Institute, and the Doolittle Institute, AFRL established PIAs with local small businesses and academic institutions that assisted them in technology transfer with the DoD. In 2014, US Special Operations Command (USSOCOM) began working with the Doolittle Institute to establish its own local innovation organization in Fort Walton Beach, SOFWERX. By 2017, the model caught on at the enterprise level and the USAF established AFWERX in Las Vegas near the Air Force Warfare Center while the Doolittle Center rebranded itself as DEFENSEWERX.[94]

Reporting directly to the vice chief of staff of the Air Force, AFWERX sees itself as "a catalyst for agile Air Force engagement across industry, academia and non-traditional contributors to create transformative opportunities and foster an Air Force culture of

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[92] Hummel and Wurster, "Department of Defense's Innovation Experiment."

[93] US Department of Defense, "Redesignation of the Defense Innovation Unit" (August 3, 2018), 1.

[94] "Who We Are," Doolittle Institute, accessed January 8, 2020, https://doolittleinstitute.org/about/.

innovation."[95] It operates on the premise that five nodes are necessary for innovation to succeed in the USAF: an intrapreneur who understands the problem, a technology partner to generate a solution, leadership engagement to ensure transfer, resourced advocates to provide funding, and the contract and legal framework to execute the solution.[96] To facilitate interaction between base-level Air Force intrapreneurs and commercial technology partners, AFWERX uses the Spark program as a ground-up innovation network. The program establishes Spark cells at each base and provides airmen with a thorough how-to guide to gain support for their ideas and link with industry partners. Further, the Chief of Staff of the Air Force (CSAF) has authorized specific squadron innovation funds (SIF) for airmen to implement their concepts. More thoroughly developed ideas can be presented at the annual Spark Tank competition where Air Force innovators pitch their designs to top leaders in the service as well as industry. In 2019, celebrity entrepreneurs Mark Cuban and George Steinbrener IV were notably present on the panel.

In addition to intrapreneur-focused Spark Tanks, AFWERX hosts pitch days for technology partners to reach military customers. At their flagship event AFWERX Fusion Xperience 2019, organizers brought together vendors with 100 proposals to solve Multi-Domain Operations (MDO)-related challenges. Sixty percent of these vendors had never worked with military clients before. Thirty of the proposals were selected for further development. This type of engagement has the potential to break down the barriers between the DoD and industry and change service culture to encourage the transfer of innovative technology to the Air Force.[97]

Although still a new organization, AFWERX has celebrated several successes since its inception. An early example of capitalizing on airmen's ingenuity is the "Brass the Bucks" project. A first lieutenant proposed purchasing a commercial off-the-shelf brass-sorting machine

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[95] "About," AFWERX, accessed January 8, 2020, https://www.afwerx.af.mil.

[96] "What is AFWERX?" AFWERX, accessed October 18, 2019, https://www.afwerx.af.mil.

[97] Jordyn Fetter, "AFWERX Fusion, MDO Challenge Drive Collaboration between Industry, Military, Academia," US Air Force, August 5, 2019, accessed January 8, 2020, https://www.af.mil/News/Article-Display/Article/1926016/afwerx-fusion-mdo-challenge-drive-collaboration-between-industry-military-acade/.

that eliminated time-intensive processes and saved the USAF $57 million. While this is an incremental cost-saving innovation, other proposals have potential to revolutionize processes. AFWERX networked a captain with software company C3 to develop an AI solution to aircraft maintenance challenges. Using an AI-based predictive maintenance algorithm for part replacement, aircraft availability could improve by twenty-five percent.[98] Since sustainment costs account for seventy percent of acquisitions, even minor improvements in this area could result in significant cost savings, while addressing DoD's top priority, readiness.[99] To date, AFWERX has played a role in awarding over 1,000 contracts to commercial technology innovators.

Analysis of Success Factors

Evaluating AFWERX through the lens of organizational design theory reveals the organization's structure to be extremely well adapted to its purpose. Although its vision is consistent with the Air Force's vision statement, "the world's greatest Air Force—powered by Airmen, fueled by innovation," AFWERX's flexible and networked culture and way of operating are antithetical to the standardized, hierarchical structure of operating squadrons and staff, making the USAF an ambidextrous organization. AFWERX reports directly to the second-highest ranking senior leader within the service, but has workspaces that are physically separate from normal operations, giving workers at each hub the freedom of creative thinking necessary for innovation. Furthermore, its structure is appropriate to the strategic context because it encourages engagement with the non-traditional partners who are driving US innovation today. Thus, through the lens of organizational design theory, AFWERX is poised for success.

[98] "AFWERX Partners with Cutting Edge AI Company to Transform Aircraft Maintenance," AFWERX, August 24, 2018, accessed January 8, 2020, https://www.afwerx.af.mil/stories/predictive-maintenance.html.

[99] John A. Tirpak, "Roper: Forget Acquisition Reform, Give Acquirers Top Cover to Go Fast," *Air Force Magazine*, April 12, 2019, accessed January 8, 2020, https://www.airforcemag.com/roper-forget-acquisition-reform-give-acquirers-top-cover-to-go-fast/.

However, historical case studies show that ideal structure is not sufficient to predict success. Other enabling factors must be present.

The first success factor observed in Skunk Works and DARPA was insulation from excessive oversight. The authorities leveraged by AFWERX grant it immunity from most bureaucratic processes. Its use of OTAs and direct access to leadership allow the unit to grant contracts in sixty days rather than the thirteen-month average of traditional processes. In fact, the use of OTAs has surged since Congress expanded the authority in 2016.[100] Moreover, granting innovation funding directly to the squadron eliminates bureaucratic red tape, allowing ground-up innovation to flourish. The AFWERX Innovation Handbook, readily available on its website, advises internal problem-solvers on how to use these squadron funds, how to shape and scope the problem they aim to solve, how to gain buy-in from stakeholders, and how to move their project forward. While an unsupportive squadron commander can remain an obstacle to advancement, several higher layers of approval have been eliminated. Further, the positive press afforded to this program incentivizes squadron leadership to support it.

The second success factor concerns the quality of both workers and top-level leadership. Since any airman at any level can make proposals to the program, it provides an opportunity for talent to rise to the top. Further, the ability to connect with non-traditional partners and academia also allows the program to select competitively from industry, assuming commercial interest is piqued. Judging by participation in the 2019 Fusion event, industry interest is growing. As for leadership, Assistant Secretary of the Air Force for acquisitions, Will Roper, has been an ardent advocate for this approach. Although a recent congressional study identified ninety-eight recommendations to streamline the acquisitions process, Roper contends that "top cover" and the willingness to take risks are all that is necessary for innovation to succeed rapidly.[101] Roper's

[100] Tajha Chappellet-Lanier, "Money Spent Through OTAs Surges to More Than $4 Billion," *Fed Scoop*, August 9, 2019, accessed January 9, 2020, https://www.fedscoop.com/otas-contracting-fiscal-2018-bgov/.

[101] Tirpak, "Roper."

risk-taking vision is supported by General David Goldfein, CSAF, who has consistently promoted AFWERX and has presided over Spark Tank panels. The future success of the initiative will depend on continued advocacy from the next CSAF.

The third factor in an organization's innovation success is the existence of specific objectives. This is the greatest area of concern for the Air Force and the DoD as a whole. Over the past six months, the Air Force has held pitch days for a wide range of topics: MDO, space, unmanned aircraft systems (UAS), hypersonics, simulators, fighter aircraft, mobility aircraft, ISR, sustainment, communications, and a future base concept.[102] Similarly, DoD modernization priorities cover a broad spectrum: AI, biotechnology, autonomy, cyber, directed energy, hypersonics, space, and others.[103] Lacking a unified strategic vision, innovators' efforts are diluted among various initiatives. However, given the broad range of commercial technology advancement, this approach may suit the context. DARPA's experience highlights that when specific DoD objectives are absent, foundational research that underlies larger technology leaps holds the most potential.

Having a strategy to transfer technology to the client is the final factor contributing to success in innovation efforts. AFWERX provides countless venues for technology developers to engage with Air Force intrapreneurs and awards contracts quickly. Because individuals familiar with the problems are the source of most initiatives, the service is more likely to have buy-in. However, this approach may not lend itself to the type of disruptive, game-changing innovation the USAF professes to seek. Even when innovators garner stakeholder support for their ideas and demonstrate successful prototypes, competition with existing programs could impede acquisition. Yet, AFWERX's how-to guide and its use of expedited authorities provide innovators with a strategy that gives them a fighting chance.

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[102] "Air Force Pitch Day Events," Air Force Small Business Innovation Research and Small Business Technology Transfer, accessed January 9, 2020, https://www.afsbirsttr.af.mil/AF-Pitch-Day/How-to-submit/.

[103] "Modernization Priorities," Undersecretary of Defense for Research and Engineering.

Final Assessment

Overall, the creation of AFWERX appears to be a well-adapted solution to the DoD's current innovation challenges, but its success will depend on continued top-level leadership advocacy and sustained engagement with industry. Its organizational design provides innovators with flexible networks, simplified processes, and physically separate workspaces to promote creativity and problem solving. DoD and Air Force decision-makers have built upon historically successful models like Skunk Works and DARPA, but adapted initiatives to the current strategic context. Leaders have insulated AFWERX from excessive bureaucracy, advocated its programs, and provided transfer strategies for its discoveries. The lack of clear, specific objectives remains an obstacle to rapid employment of game-changing technology, but the foundational technology advancement AFWERX provides has the potential to enable greater breakthroughs in the future when a specific threat emerges. As long as DoD and USAF leadership persist in their support for disruptive innovation and continue to adapt to industry realities, the US military has a high potential for maintaining its competitive advantage over its adversaries.

Conclusion

This monograph has developed the hypothesis that an ambidextrous structure is the most suitable design to encourage the adoption of disruptive innovation in large, competitive organizations when accompanied by appropriate leadership. Organizational design theory supports the value of structure in creating a successful organization while acknowledging that structure alone is not sufficient for success. The historical case studies of Skunk Works and DARPA provide insight into additional non-structural factors that enabled their achievements. These cases suggest that when an organization with ambidextrous structure is insulated from bureaucratic processes, has strong senior leader support, pursues clearly defined objectives, and has a strategy to transfer technology to the user, it is likely to succeed in harnessing disruptive

technology in a competitive environment. Given their critical role in generating a competitive advantage, leaders must be prepared to adapt their strategies, objectives, and structure as the context changes.

Recognizing changes in the strategic environment, the DoD has called upon its leaders to organize for innovation. Because the creation of AFWERX leverages an ambidextrous structure, applies success factors from historical experience, and accounts for current strategic realities, it is a well-informed response to the DoD's call. With continued support for innovation from senior leaders and perpetual vigilance for strategic change, the DoD is poised to maintain its competitive edge.

While the monograph identifies applicable theory and observations from successful organizations, it represents neither an exhaustive study of all organizational structures nor a complete examination of all DoD attempts to innovate. Further research is necessary to make any definitive claims about the best structure for harnessing innovation. The theory and case studies presented refute the idea that large bureaucratic organizations are unable to harness innovation, but there is not enough evidence to guarantee these conditions are generalizable to all cases. Indeed, considering the variety of structures, the complexity of human factors, and the uncertainty of a constantly evolving strategic environment, organizational success may not be predictable with any confidence. However, as strategist Colin Gray professes, "The key to victory here is not the expensive creation of new conceptual, methodological, or electro-mechanical tools of prediction. Rather it is to pursue defense and security planning on the principles of minimum regrets and considerable flexibility and adaptability."[104] This author holds that the DoD's current initiatives adhere to these principles.

[104] Colin Gray, "21st Century Security Environment and the Future of War," *Parameters* (Winter 2008-2009): 19.

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